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DEVELOPMENT OF DISSOLVED OXYGEN PROBE CLEANING APPARATUS

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Federal Water Pollution Control Administration
Portland, Oregon

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U S Department of Commerce
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U. S. Department of the Interior
Federal Water Pollution Control Administration
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DEVELOPMENT OF A DISSOLVED OXYGEN PROBE CLEANING APPARATUS FOR AUTOMATIC WATER QUALITY MONITORS

INTRODUCTION

The Federal Water Pollution Control Administration operates a network of water pollution surveillance stations throughout the United States, consisting largely of automatic monitors emplaced on rivers and streams to record water quality changes throughout the year. Three such stations are located on the lower Willamette River near the Northwest Regional Office of the FWPCA.

The Willamette suffers from serious pollution as a result of the discharge of pulp and paper mill wastes. During the summer low-flow, high water temperature period, these wastes depress oxygen and create sludge banks and slime growths.

The automatic monitors in this area serve as a crucial information source in water quality management to protect desired water uses, particularly fish migration. During the critical period, the data must be keyed to weather and streamflow forecasts to allow management agencies to maintain water quality above minimum levels.

Insuring the accuracy of the monitor data is the most important function of the data gathering process. And the experience of the three years during which the Willamette has been monitored shows that the pollutants--especially the slimes--necessitate frequent cleaning of the monitoring equipment to insure that accuracy. The following pages describe the device which was developed to reduce the maintenance time and expense required for accurate water quality information from automatic monitors.

THE PROBLEM

In 1963, two tube-type automatic water quality monitors were installed in the Lower Willamette River. Each monitor measures and records the following parameters: pH, dissolved oxygen (DO), temperature and conductivity.

A schedule of routine maintenance of the monitors was established for summer months because of the buildup of biological slimes, primarily on the dissolved oxygen probe. These slimes change the sensitivity of the sensor, leading to incorrect measurements. Temperature and pH are not affected beyond the limits of accuracy of the instrument, and the conductivity is not affected any greater than one percent of fullscale.

By the spring of 1966, three years of membrane cleaning experience on the DO sensor probe was accumulated. This indicated that during times when streamflow was low and water temperatures were up from winter lows, the probes had to be cleaned daily by physical and chemical means to insure greatest accuracy.

In 1966 a third monitor was added to the Lower Willamette network. It measures and records pH, temperature and DO. Daily cleaning of the DO sensors of all three instruments requires a 65-mile round trip of urban driving and approximately four hours of a technician's time.

In order to save time and money and to increase the unattended accuracy of these monitors, it is desirable to have this cleaning accomplished automatically. The number of visits to each monitor could then be reduced from once daily to once weekly. Weekly maintenance is sufficient for the other parametric systems and is also a suitable time period for picking up the printed recorder strip chart for weekly analysis and reporting.

THE SOLUTION

A search was made among the purveyors of timing devices to operate a cleaning device and nothing suitable could be located. In view of this, a timing and cleaning device was designed, constructed and tested.

Design criteria included essential compactness, low initial cost, reliability in repeating the cycles of operation, and close tolerances due to the small space available around the sensor itself.

The cleaning is carried out by a brush that passes across the membrane twice in each cycle of operation, and this cycle is repeated once each hour. The timer fits into the flow cell cubicle of the monitors now in operation and can readily be attached to the top of the flow cell. The brush mechanism is mounted on the DO probe itself by means of a modified membrane retainer ring and is operated by a pushrod through the stopper between the brush and the timer. This fits into the present flow cell along with the DO probe and its temperature compensator. The flow cell can also accommodate a temperature probe with the device installed. A more detailed description of the device is appended.

In the two months of testing operations of this device there were no changes made in any part of the mechanism. It operated on the same membrane during this period. The results of checking the monitor DO data against weekly Winkler test data are listed below for the period of operation of the DO sensor cleaning device (see TABLE 1). A comparable period for the previous year is shown for comparison (see TABLE 2). Cleaning of the system was done on a weekly basis except as noted.

As noted in the tables, the streamflow and temperatures for the two periods were comparable. The volume of pulp mill waste discharges from daily production and from lagoon discharges held over from the previous season were comparable.[1/] Therefore, the conditions necessary to cause a nuisance growth of slime were comparable for each period.

From the tables it is apparent that the cleaning device has been able to control the slime production on the membrane.

The device, then, satisfies all criteria. It is compact and easily attached to present equipment; it is inexpensive; it is reliable in that it has not failed to operate each hour since it has been installed; and it repeats the exact cycle each time it operates.

1/ According to OSSA records

TABLE 1

WITH CLEANING DEVICE
March-April
1967

Date	Recorded Temperature	Recorded DO	Winkler DO	Discrepancy	Salem cfs
3-14-67	45.6	9.5	9.7	0.2	16,100
3-21-67	47.8	10.0	10.0	0.0	23,800
3-28-67	47.7	9.1	9.7	0.6 *	19,300
4-4-67	50.5	9.3	9.4	0.1	15,400
4-11-67	52.4	8.9	8.9	0.0	12,800
4-19-67	47.8	9.3	9.4	0.1	15,900
4-25-67	55.4	7.8	7.9	0.1	15,000
5-2-67	53.5	8.4	8.8	0.4 *	15,400
				1.5	
			Ave.	0.19 discrepancy	

* Tube malfunction in analyzer.

TABLE 2

WITHOUT CLEANING DEVICE

March-April
1966

Date	Recorded Temperature	Recorded DO	Winkler DO	Discrepancy	Salem cfs
3-17-66	46.3	9.2	10.6	1.4	45,900
3-24-66	47.2	8.7	11.0	2.3	32,600
3-31-66	51.8	8.8	9.8	1.0	27,800
4-7-66 1/	54.2	8.4	8.9	0.5	23,800
4-14-66 1/	49.5	10.1	10.3	0.2	25,800
4-21-66 1/	52.8	8.6	8.9	0.3	16,100
4-28-66 1/	55.0	8.1	8.4	0.3	14,300
5-5-66 1/	62.7	6.8	7.4	0.6	15,900
				6.6	
			Ave.	0.83 discrepancy	

1/ Semi-weekly visits

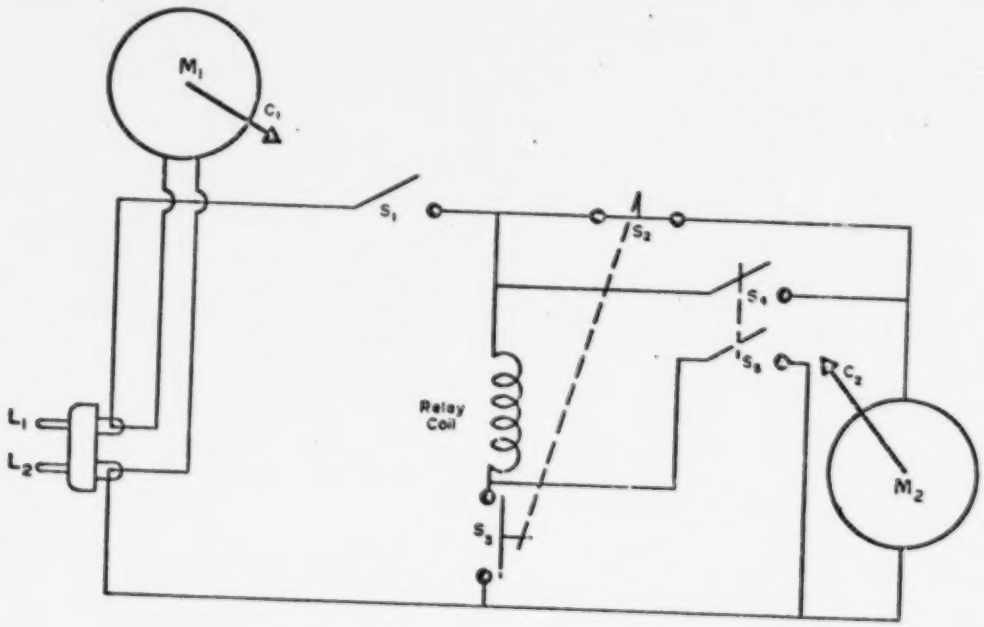
APPENDIX

APPENDIX

DETAILED DESCRIPTION OF DO PROBE CLEANING DEVICE

The timer involves three micro switches, a D.P.D.T. relay, a one RPM synchronous motor with 60to1 reduction gears, and a 12 RPM output operating motor as a prime mover to the cleaning mechanism.

Following is a straight line schematic of the timing and operating unit and an explanation of its operation:



M_1 - Synchron A43RA RPM synchronous motor, 115V AC-60cy-3watt with 60to1 reduction gear. $7.65 ea.

M_2 - Dayton Mod 3M107, 115V AC-60cy-0.2amp, 12 RPM ratiomotor. $2.69 ea.

S_2S_3 - Potter Brumfield KA11AY, D.P.D.T. relay-115V-60cy coil. $4.05 ea.

$S_1S_4S_5$ - Micro 11SM1, S.P.D.T. $1.02 ea.

C_1 - Output shaft flat on M.

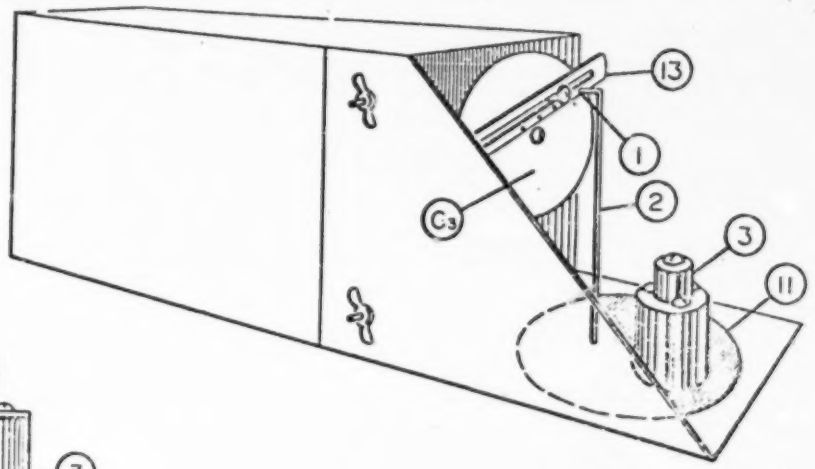
C_2C_3 - Made from SC25 Boston gear set collars and circle cut steel sheet.

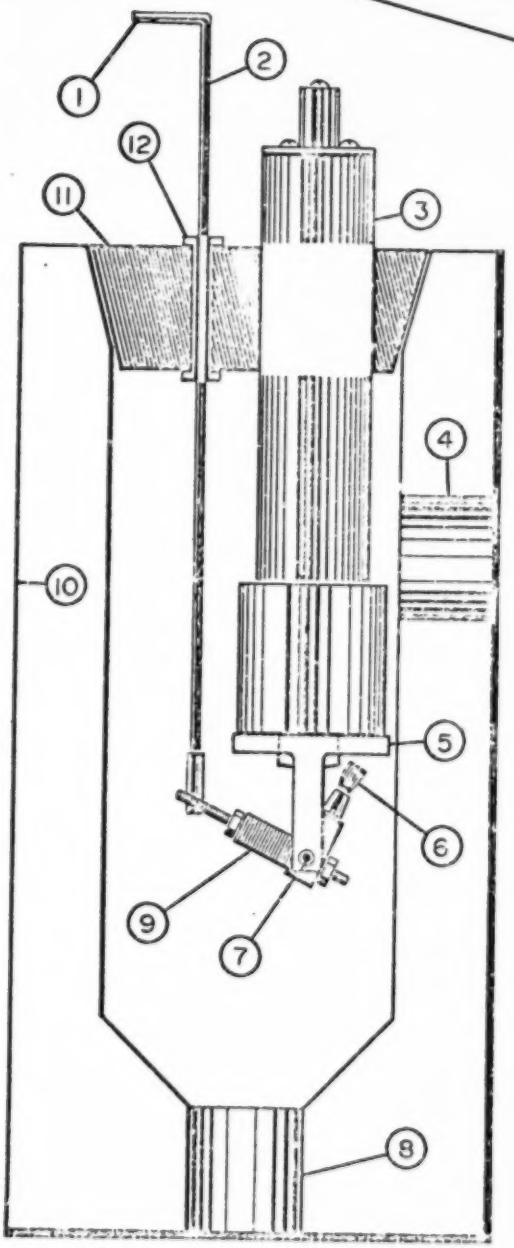
L_1L_2 - Cinch Jones interlock male connector.

Box - BUD #CU-2195-A, Minibox 5x-4w-3h. $1.40 ea.

Once each hour M_1 closes switch S_1 with cam C_1. This allows current to flow through N.C. contacts switch S_2 and through the motor M_2 the operating prime mover. Cam C_2 on M_2 then operates switches S_4 and S_5. S_4 parallels S_2. S_5 parallels S_3 and also operates relay which closes S_3 and opens S_2. S_3 then acts as a holding contact to keep the relay operated. The end of the first revolution of Cam C_2 then opens switches S_4 and S_5 removing power from motor M_2. Switch S_1 and S_3 are still closed, keeping relay operated until Cam C_1, on M_1, opens S_1 which removes power from relay allowing S_2 to close and S_3 to open re-arming the system to await the next closure of S_1 by C_1 on M_1.

For the mechanical operation, please refer to the following drawings and explanation.





LEGEND

1. Point of connection to timer assembly.
2. Pushrod.
3. Dissolved oxygen probe
4. Water outlet.
5. Modified membrane retainer ring.
6. Cleaning brush.
7. Pivot.
8. Water Inlet.
9. Adjustable bell crank.
10. Lucite flow cell.
11. Rubber stopper.
12. Brass bushing.
13. Walking beam.

C_3 Cam on outputshaft of operating motor M_2.

The cleaning mechanism is attached to the submerged end of the DO probe. The attachment is by means of a modified membrane retainer ring. The ring is modified by two supports that hold the brush and bell crank pivot bar.

Cam C_3 is located on the output shaft of operating motor M_2 as discussed in the timer operation. Cam C_3 causes a walking beam (13) to change rotary motion to linear motion. The linear motion is transmitted by pushrod (2) to cleaning brush (6) through bell crank (9). The cleaning cycle is composed of one brush stroke in each direction. The brush comes to rest in a position away from the membrane and out of the line of water flow across the membrane.

Modifications to present equipment are simple and are such that the flow cell remains in place to accept them. Four holes tapped to take #4/40 x 1/2" machine screws hold the timer and timer mounting bracket to the top of the flow cell. A modified membrane retainer ring is attached to the DO probe. A hole is drilled through the rubber stopper to accommodate a brass bushing for the pushrod.

The method of holding the DO probe in the stopper is not altered. This is used as a means of adjusting the resting point of the brush. All other parts on the stopper remain in place.

With both rotary and linear motion available, the cleaning mechanism could use a rotary brush that could be swung into contact with the membrane. In this case, the membrane may be recessed instead of projecting.

An additional aid of metering a chlorine solution to the brush, during the cleaning cycle, may readily be added. A chlorine solution has been used with good results in control of biological slime growths for short periods.